RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #7

Simulation of MOPS Bench Tests

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SUMMARY
Our Working Group has drafted performance requirements in the form of minimum reception probability under certain controlled conditions, but the specific values remain to be specified. As a means of developing these values, Lincoln Laboratory is using two techniques, one based on simulation and the other based on bench tests. The FAA Technical Center is doing similar studies. The simulation portion of the work is progressing well. This Working Paper presents recent simulation results, and describes the current status and plans for further work.

Simulation of MOPS Bench Tests

In order to develop values of reception probability for the MOPS requirements and tests, Lincoln Laboratory is conducting simulations under controlled conditions. For example, to correspond with the draft MOPS test in which a single ATCRBS fruit is overlapping the Extended Squitter signal, this same condition is being created in simulation, and the reception probability is being determined by Monte Carlo trials. Similar work is in progress at the Tech Center.

This working paper describes the formulation of the simulation work and planned bench tests, and gives recent results. At the previous WG3 meeting, I presented a similar working paper, giving the status at that time (WP-6-12). For ease of reading, this paper will repeat some of the introductory material so that it can stand alone.

The simulation we are using can be thought of as being in two parts, as illustrated in Figure 1. The first part generates the received signal, consisting of an Extended Squitter signal, plus ATCRBS interference, and receiver noise. This combination is generated in the form of log-video, sampled at a rate of 8 samples per microsec. Using this technique it is possible to overlap an Extended Squitter signal with 3, or some ATCRBS fruit receptions, or some other number, and to make their timing random, overlapping the data block. In another case the interference can be made to overlap the preamble.

The second part of the simulation, called "Reception Techniques", represents the receiver, including the techniques for detecting and demodulating the signal, estimating the 112 bits and the associated confidence bits, and finally error detection/correction. This is currently being done using the enhanced reception techniques, but can also be done for the current TCAS reception techniques, or other defined techniques.

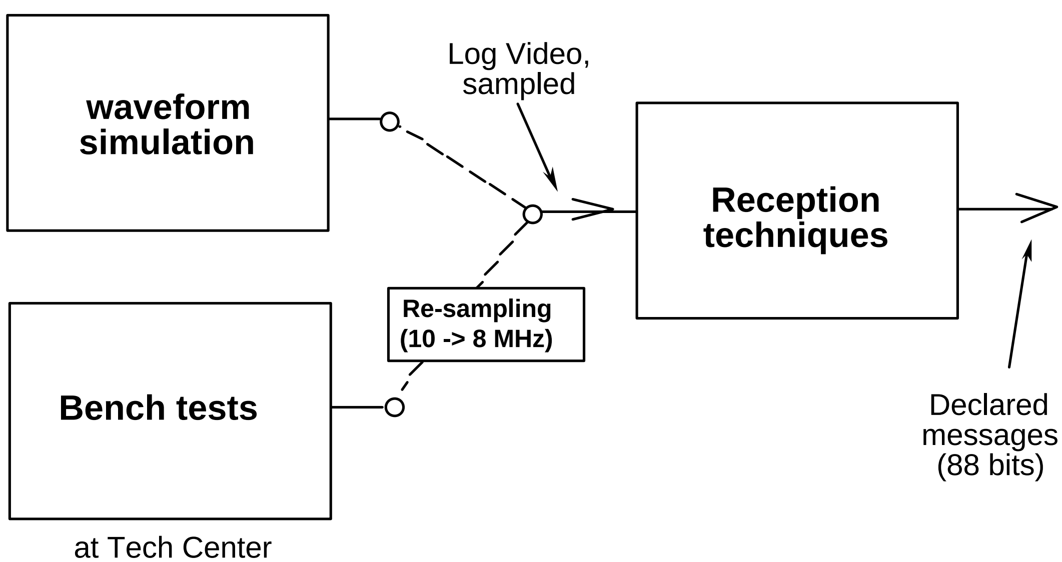

Figure 1. Main functions of the simulation and bench tests.

Figure 1 also shows another way of getting results, using bench tests instead of the waveform simulation. The bench test approach is planned to be used in the future.

The initial results presented at the previous meeting have now been extended. Simulation results are given in Figure 2. A number of reasonableness checks have been done, so that now we have built up confidence that these results are correct.

The results in Figure 2 apply to cases corresponding to the MOPS tests we have drafted. In this case, an Extended Squitter signal is being overlapped with ATCRBS fruit, having power of -65 dBm (which is 20 dB above the receiver threshold). For 2 or more fruit overlaps, both have power of -65 dBm. The timing of each fruit is random, uniformly distributed between +8 and +120 microsec. relative to the beginning of the Extended Squitter signal. Results are shown here as a function of received signal power. This is the same format that was used in earlier working papers, presenting bench tests that were performed on an LDPU. The figure shows the results for 1, 3, and 5 interferers. Simulation results were also obtained for 0, 2, and 4, but are omitted from this plot for clarity.

The results in Figure 2 are seen to be similar to the LDPU bench tests. When the signal is stronger than the interference, reception probability is essentially 100%. When the signal power is reduced such that it is approximately the same as the interference, reception probability is seen to be degraded. If the signal power is reduced further, reception probability improves significantly. This same behavior was seen previously in LDPU performance.

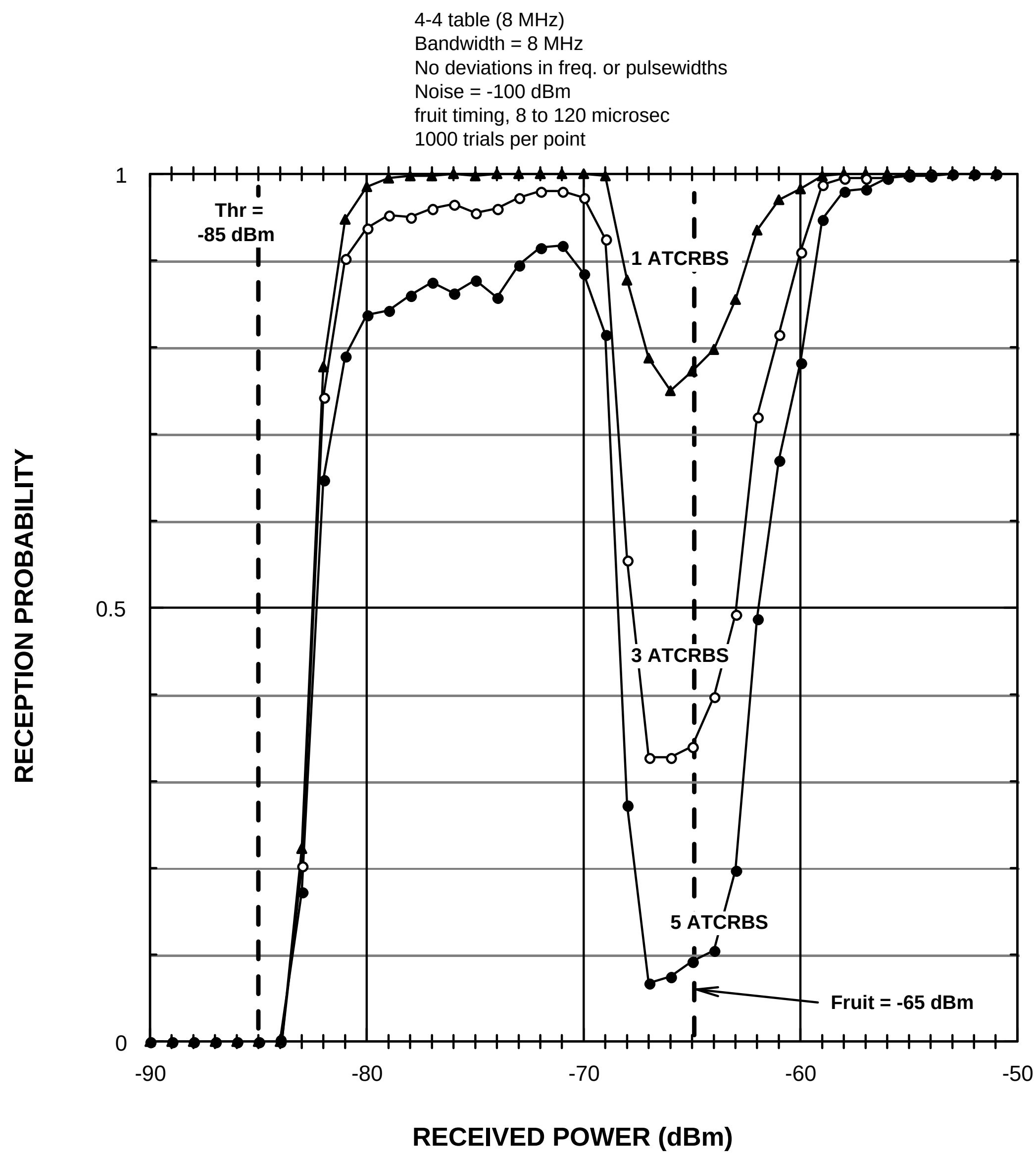

Figure 2. Simulation results, for ATCRBS fruit overlapping the data block.

Having this simulation capability is useful because many of the specific conditions can be changed. For example, we can readily change the interference power, or the receiver threshold, and get results for comparison. Figure 3 shows such results, where the interference power has been reduced to -70 dBm.

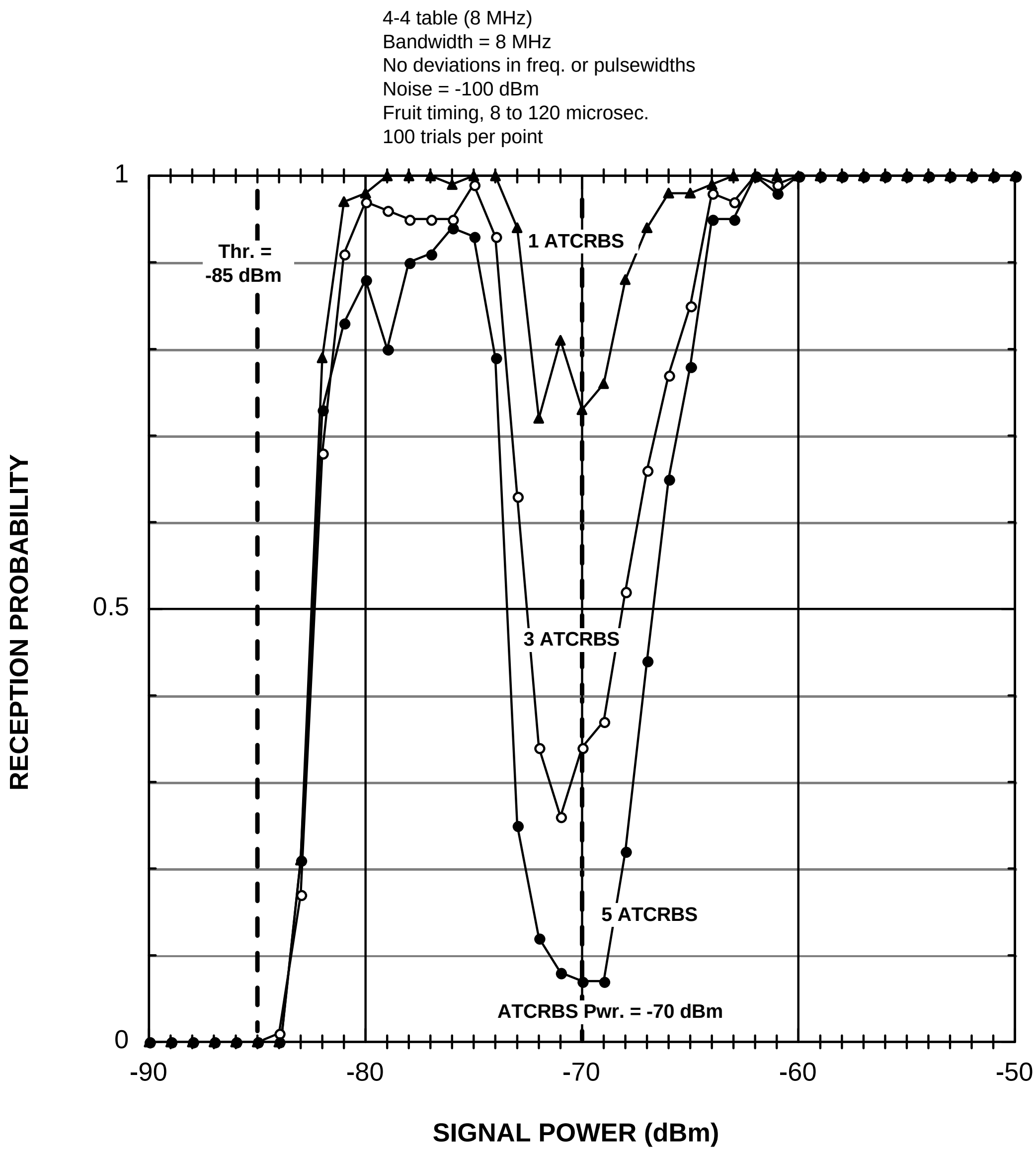

Figure 3. Simulation results for a different interference power.

These results indicate that a change in the power level of the interference causes mainly just a horizontal shift in the performance curve. Evidently, as might be expected, reception performance depends mainly on the signal-to-interference ratio, not on the absolute powers relative to threshold or receiver noise. One other difference in this plot relative to Figure 2 is that only 100 trials were used here for each point. Using a greater number of trials improves the accuracy of the results, so there is more variability in the Figure 3 results, but the trends are clearly evident with this level of accuracy.

The simulation can be run with or without random deviations in carrier frequencies and pulsewidths. When used to determine performance in airborne operation, we normally include these deviations, but in bench tests the situation is different: the carrier frequency of the signal and of each of the interference generators will remain constant. To investigate the effects on performance, we have run the simulation both ways. In the results presented above, the frequency and pulsewidth deviations were zero. In Figure 4, these deviations were made variable as in an airborne environment. Specifically, to model frequency deviations, we used a uniform distribution over +/-1 MHz for the Extended Squitter signal, and over +/-2 MHz for the ATCRBS interferers. To model pulsewidth deviations, we used a uniform distribution over +/-25 ns for the signal and over +/-50 ns for the interferers.

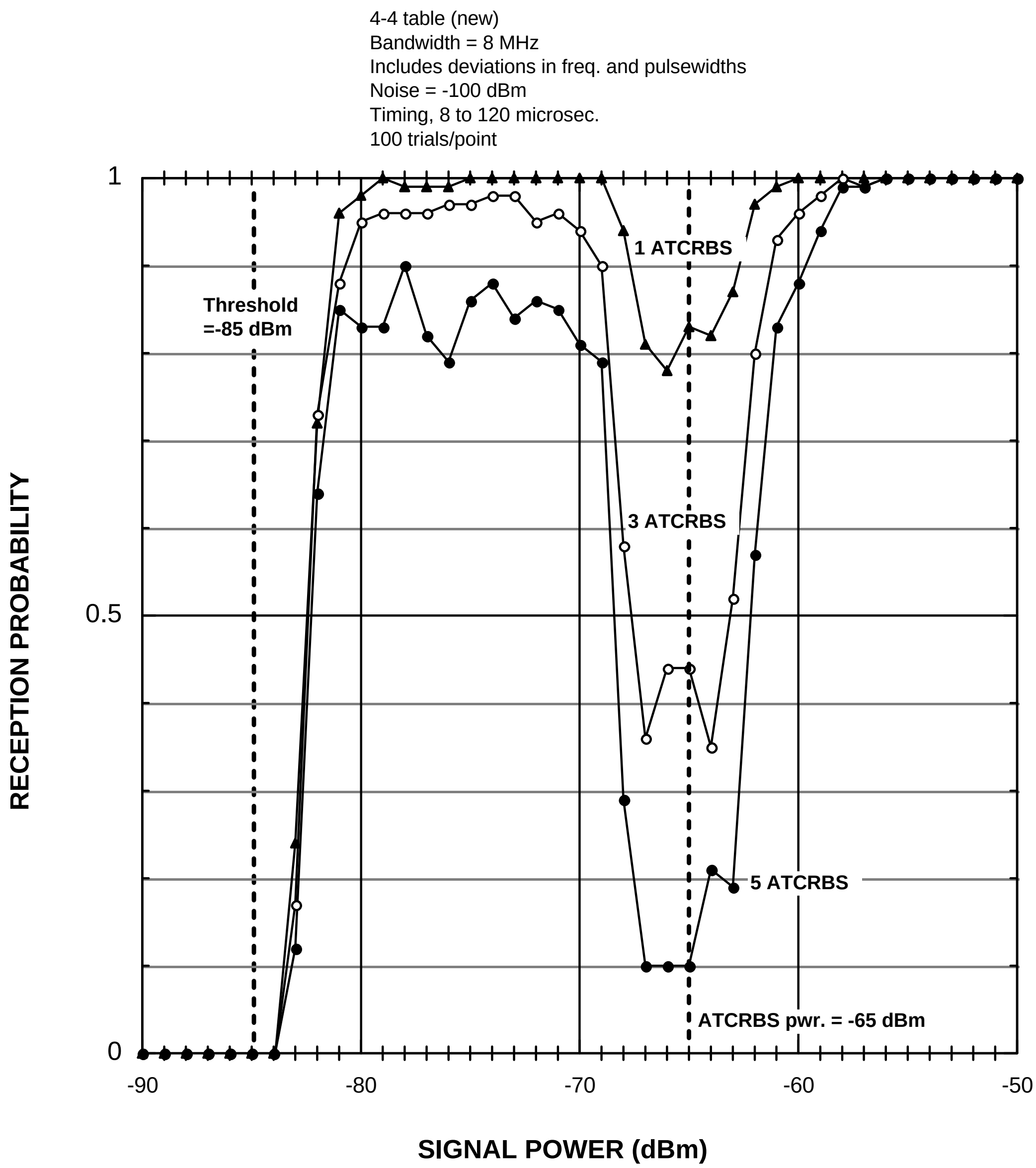

Figure 4. Simulation results including freq. and pulse width deviations.

Comparing these results (Figure 4) with the corresponding results in Figure 2, we see that the deviations cause a minor improvement in reception performance.

These graphs summarize the status of our work as of this meeting. I am working with John Van Dongen to compare our results in detail with corresponding data he has generated.